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Effect of Nitrogen Concentration on the Performance of Single-Chamber Microbial Fuel Cells

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Abstract

The nitrogen removal in wastewater using single chamber microbial fuel cells is an interesting process. The nitrogen removal from nitrogen wastewater was examined using single chamber air cathode microbial fuel cells (SC-MFCs). SC-MFCs were fed with synthetic wastewater containing the initial chemical oxygen demand (COD) 1,000 mg L^{-1} and nitrogen (N) 125, 250, 625, and 875 mg-N L^{-1}, respectively and operated under mesophilic batch mode. Performance of SC-MFCs with external resistances 1,000 Ω was based on maximum power density, COD and nitrogen removal. The SC-MFCs with ammonia-N concentration 625 mg-N L^{-1} gained higher maximum power density by 160 mW m^{-2}.The ammonium removal was 58 %. The results suggested that SC-MFCs are potential technology for simultaneous nitrogen and COD removal; and electricity generation.

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Keywords: single chamber microbial fuel cells; nitrogen removal; synthetic wastewater; external resistance; power density

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1. Introduction

The nitrogen wastewater treatment technology is an important process to remove nutrient pollutant. The nitrogen wastewater is a major impact due to its primary role to the impact on eutrophication of water bodies and on human and animal health [1]. The removal of nitrogen in the wastewater is difficult in one process. There are two reactions in nitrogen removal; nitrification is oxic ammonia oxidation, and de-nitrification is anoxic nitrate reduction. It is require to multiple reactor used for nitrogen wastewater treatment with oxic and anoxic condition. While the SC-MFCs can be simultaneously generate electricity and treat nitrogen in the wastewater. The nitrogen removal in SC-MFCs can be occur nitrification and de-nitrification because there are anoxic in anode and air- cathode in one reactor. SC-MFCs are interesting for nitrogen wastewater treatment in one process. This process is lower operation cost than other process that requires more than one process. In this study, the limitation of ammonia-N for nitrogen removal and generating electricity were investigated.

2. Material and method

2.1. SC-MFCs configuration and operation

The experiments were using air- cathode single chamber microbial fuel cell constructed as a previous describes, Liu and Logan, (2004) [2]. SC-MFCs were operated in close circuit condition (electricity generation) to investigate the effect of power, current, and nitrogen removal in fixed COD concentration and vary ammonia-N concentration. SC-MFCs were operated in batch mode with temperature 37 ^{o}C and pH was 7.

2.2. Synthetic wastewater

The synthetic wastewater for SC-MFC modify from Jadhav and Ghangre, (2008) [3]. The synthetic wastewater had fixed COD concentration 1,000 mg L^{-1} and varied ammonia-N concentration 125, 250, 625, and 875 mg-N L^{-1}, respectively. Synthetic wastewater was autoclaved at 121 ◦C for 15 minutes before use.

2.3. Analytical procedures and calculations

Power density was calculated by monitoring voltage across the resistor in circuit using a multimeter with a data acquisition system. Power density was obtained using P = IV/A, where I (A) is the current, V (V) is the voltage and A (m^2) is project surface area of the anode [4]. The nitrogen and COD removal were analyzed during the test according to APHA Standard Method [5].

3. Result and discussion

3.1. SC-MFCs performance

The carbon source of SC-MFCs was fixed at 1,000 mg COD L^{-1}. The effect of ammonia-N concentration in the system was shown in Fig 1. The power density with ammonia-N was dropped at ammonia-N concentration of 875 mg-NL^{-1}. The high ammonia-N wastewater dropped the power density since nitrification and de-nitrification present in SC-MFCs. The requirement of de-nitrification reaction

was electron to occur reaction. The de-nitrification had reduction step toward to nitrogen gas (N_2) using 5 mole electron per mole of nitrogen [6], thus high nitrogen wastewater takes electrons from system.

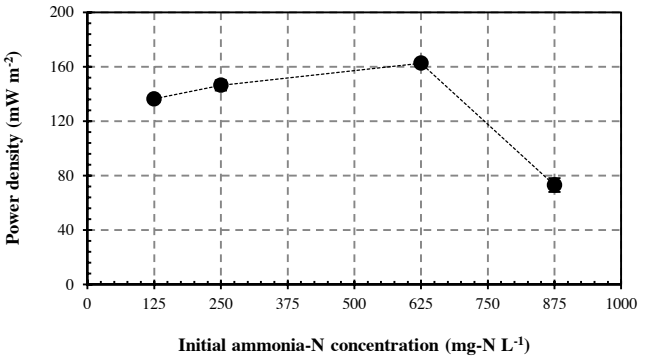

Fig. 1. Power density in varying initial ammonia-N concentration.

3.2. Ammonia-N removal

The milligram of ammonia-N and percentage of ammonia-N removal was shown in Fig 2. The highest percentage of ammonia-N removal was detected in ammonia-N concentration 825 mg- NL^{-1} was 72% of batch test. The percentage of ammonia-N removal of concentration 125, 250, and 625 mg- NL^{-1} was 50 to 58% that lower than 825 mg- NL^{-1}. The way of ammonia-N removal was assimilation and dissimilation. The dissimilation is nitrification and de-nitrification. The conversion of nitrogen removal is based on autotrophic nitrification and heterotrophic de-nitrification [7]. The requirement of de-nitrification reaction was electron to occur reaction. The de-nitrification had reduction step toward to nitrogen gas (N_2) using 5 mole electron per mole of nitrogen [6], thus high nitrogen wastewater was catch electron from system. Therefore, the removal from highest of ammonia-N concentration (825 mg- NL^{-1}) that generated lowest of electricity.

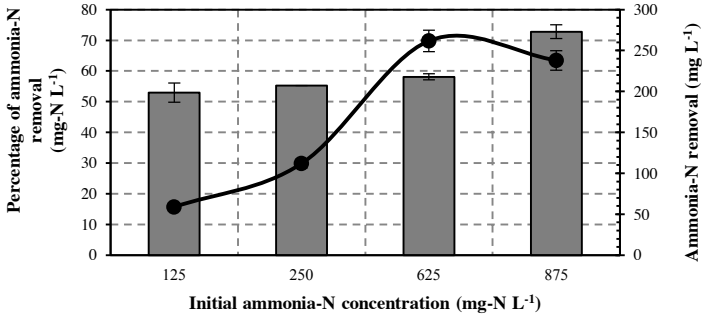

Fig. 2. Ammonia-N removal in varying initial ammonia-N concentration.

3.3. COD removal

The milligram of COD removal was decreased when ammonia-N concentration was increased to 825 mg- NL^{-1}(Fig 3). The higher percentage of COD removal was show at ammonia-N concentration

125 mg- NL^{-1}, 250 and 625 mg- NL^{-1}(90-93 %), respectively. The highest of ammonia-N concentration was limited COD removal and power density in the system. Therefore, suitable of nitrogen concentration for SC-MFC was 625 mg- NL^{-1} because it was highest of electricity generation, and 90% of COD removal.

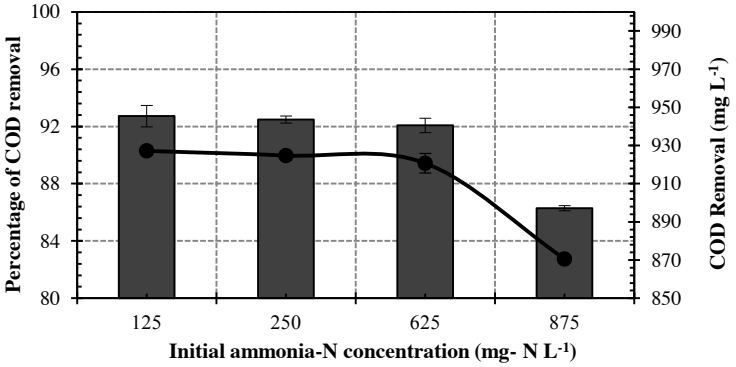

Fig. 3. COD removal in varying initial ammonia-N concentration.

4. Conclusion

This study has demonstrated the effective of nitrogen wastewater treatment efficiency for electricity generation in SC-MFCs. The removals of nitrogen as well as nitrogen compounds are interesting process. The removal nitrogen processes are via assimilation and dissimilation (nitrification and de-nitrification). The dissimilation was decomposing organic and inorganic matter convert to energy and assimilation deals with the synthesis of proteins as well as protein compounds use for cells. The best performance of SC-MFCs was gained the ammonia-N concentration 625 mg- NL^{-1}.

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